Glass and Ceramics, Vol. 70, Nos. 5 – 6, September, 2013 (Russian Original, Nos. 5 – 6, May – June, 2013)

EQUIPMENT

UDC 666.1:666.3:621.928.8

SEPARATOR FILTER FOR IRON IMPURITIES IN CERAMIC SUSPENSIONS. MAGNETIC FIELD IN MATRIX PORES

A. A. Sandulyak,[1, 2] A. V. Sandulyak, and D. V. Ershov[1]

Translated from *Steklo i Keramika*, No. 6, pp. 25 – 27, June, 2013.

A prospective application of magnetic separator filters with a filtering matrix for purifying ceramic suspensions is examined. Previously lacking characteristics of the relative intensity and induction of the magnetic field in the pores of a hemispherical matrix of a filtration-type magnetic separator used for removing iron impurities from ceramic suspensions are obtained.

Key words: ceramic suspension, iron impurity, magnetic separator filter, in-pore field.

A promising method for removing iron impurities from ceramic suspensions is by means of a magnetic separator with a filtering (activated by a magnetic field) matrix [1] in whose pores a magnetic field with quite high intensity (induction), much higher than that of the magnetization field itself, i.e., the field acting on the this matrix, is created [2].

As concerns the characteristics of the field intensity (induction) directly in the pore channels of a matrix filter (where the medium purified of iron impurities actually passes), determining such a characteristic is considered to be a quite difficult problem [3 – 6], mainly because of the smallness of these pores for making direct measurements.

At the same time this characteristic can be determined. This requires using an experimentally proven, novel, successful model of the channel magnetization of a granular (hemispherical) medium [2].

In such a medium, which consists of many chaotically arranged granule-links of a branching skeletal structure [2], chains of granules (mainly twisting chains) always become apparent in reality. This is what predetermines the selective (channel) magnetization of a granular medium [2]; the effective magnet-channels formed (as a ‘family’ or ‘rope’) along the direction of magnetization and manifesting as chains in conformity with the contacting granules are responsible for the magnetization of the medium.

This model, which makes it possible to obtain an entire series of fundamentally new solutions [2], also makes it possible to solve the problem of determining the intensity h in a modular pore (for some intensity of the magnetizing field H) depending on the working distance r to the contact point of the spheroidal granules of radius R. Specifically,

$$\frac{h}{H} = \frac{\mu}{\mu - \sqrt{1-(r/R)^2}\,(\mu-1)}, \tag{1}$$

where h/H is the relative intensity of the magnetic field and μ is the magnetic permeability of the material of the granules (in the field H).

A magnetizing field that is not as strong but fully sufficient to activate the matrix is created in the ceramic separator filters, usually used to remove iron impurities from ceramic suspensions, with an internal magnetic block and the matrix encircling it [1].

The characteristics, obtained using Eq. (1), of the relative intensity of the magnetic field in a modular pore (the space between granules) for different values of H are shown in Fig. 1*a*: 10, 20 and 30 kA/m. The average values of the induction B in the granular (hemispherical) matrix and the magnetic permeability μ are, respectively, 0.13, 0.21 and 0.31 T [2, 7] and 140, 75 and 52 [2].

Evidently, the intensity h of the magnetic field in the pores is much higher than the intensity H of the magnetizing field.

The corresponding characteristic of the induction B in a pore is also very revealing. Examples of such characteristics are displayed in Fig. 1*b*. Here the values of B were calculated as $B = \mu_0 h$ for fixed values of h (Fig. 1a) and the established value of the magnetic constant μ_0 (the magnetic permeability of the content of the pores is close to 1).

[1] Moscow State Civil Engineering University, Moscow, Russia.
[2] E-mail: a.sandulyak@mail.ru.

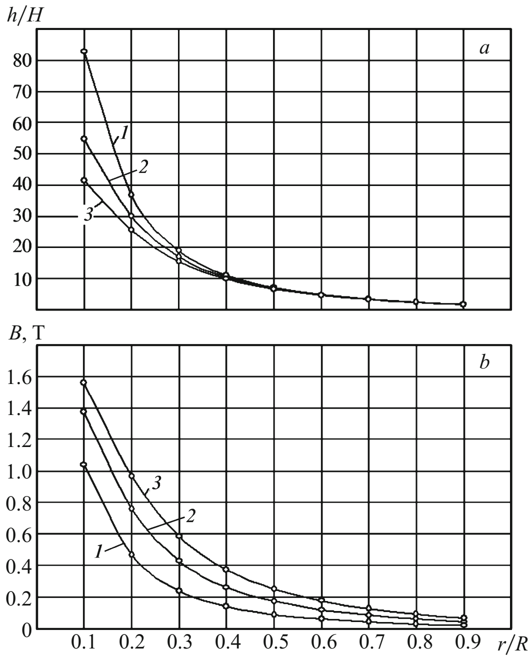

Fig. 1. Characteristics of the relative intensity h/H (*a*) and induction B (*b*) of the field between spheres in a hemispherical medium: *1*) $H = 10$ kA/cm, *2*) $H = 20$ kA/m, and *3*) $H = 30$ kA/m.

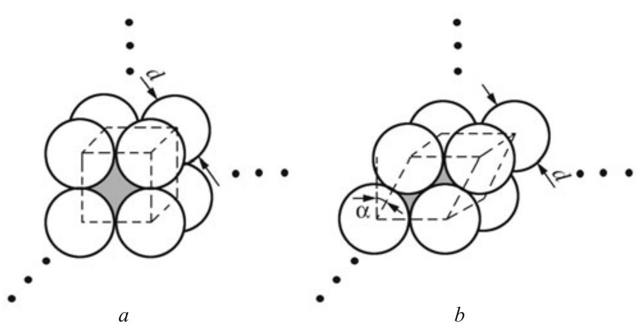

Fig. 2. Classical (*a*) and model (*b*) structures of spheres with conventionally defined ('cut out') cells [1, 7, 8].

At the same time it should be noted that the base working relation (1) was obtained for the ideal case of rectified chains of spheroidal granules. And, even though data showing that for a twisting chain of spheroidal granules the magnetic flux passes through such a chain with practically no losses right up to the twist angle 30 – 40° are presented in [2, 7], the actual (average) twist of the chains of spheroidal granules in a granular medium was not previously determined. This can cast doubt on the possibility of making full use of the working relation (1).

The controversy apropos of this is partially resolved in [2]. The twisting of a chain of spheres can be characterized quantitatively by an appropriate coefficient k, the ratio of the total chain length to the distance between the most extreme spheres in the chain or, equivalently, the ratio of a characteristic section-link of the chain to its projection on the chain's 'directional' line.

For a classical cubic structure of spheres with characteristic fractional cells [1, 7, 8] (see Fig. 2*a*) $k = 1$, since the chains of spheres in the direction of the three coordinate axes are rectilinear. But in such a characteristic ordered structure [1, 7, 8] (Fig. 2*b*), which in terms of the volume concentration of the spheroidal granules ($\gamma \cong 0.6$) and the coordination number ($Z = 8$) is closest to the structure of the fill consisting of spheres, rectilinear chains are formed along two axes (here $k = 1$). In the direction of the third axis the chains of spheroidal granules are twisting with twisting coefficient $k = 1.15$ (this value is easy to calculate using the geometric characteristics of the corresponding fractional cell shown in Fig. 2*b* [1, 7, 8]: $k = 1/\cos\alpha = 1/\cos 30°$).

On the whole, calculating a simple average of three values of k (1, 1, 1.15) for such a medium, which to a certain extent models the fill medium, the value $k \cong 1.05$ can be adopted. Therefore, the average twist angle of the chains of spheroidal granules in the adopted model (ordered) granular medium (see Fig. 2*b*), determined as $\alpha = \cos^{-1}(1/k)$, is of the order of $\alpha \cong 18°$.

Hence, even in a medium comprised of naturally packed spheres (fill) with 'strong' apparent twisting, the twisting coefficient, reaching locally $k = 1.15$ ($\alpha \cong 30°$), is on average only $k \cong 1.05$, while the twist angle $\alpha \cong 18°$. This is much smaller than the angle ($\alpha = 30 – 40°$) at which a decrease of the magnetic flux through a chain of granules first becomes noticeable [2, 7].

In summary, it is obvious that the twisting factor for chains of granules in a fill comprised of granules does not in any way impede the use of the base relation (1) for obtaining the corresponding characteristics of the magnetic field in the matrix pores of a separator filter.

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